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Future vernaculars towards a process-based dwelling ecosystem in pacific atoll nations

Miller, James, Xiaonuan, Sun and Bunza, Matthew

Title: Future Vernaculars

Towards a Process-Based Dwelling Ecosystem in Pacific Atoll Nations

James Miller[1], Sun Xiaonuan[2], and Matthew Bunza[3]

[1]Faculty of Design, OCAD University

jamesmiller@faculty.ocadu.ca,

[2]School of Urban Design, Wuhan University

sunxiaonuan@foxmail.com

[3]Metaamo Studio (Architecture firm based in US / HK)

matt@metaamo.com

Abstract

Given the already-devastating effects of climate change in Pacific atoll nations, there is an urgency to establish frameworks that support systemic sustainability and resilience within these regions. The evolution of vernacular architecture and community processes needs to be investigated and analyzed. Fundamentally, there is little understanding of: (1) what resilience means, in the context of architecture, building cultures, and localized networks; (2) the intricacies of socioeconomic, cultural, and political fabrics within which projects are pursued; and (3) how to balance soft and rigid approaches to achieving high-performance building and community solutions, while still remaining low impact in the context of localized material loops and building cultures.

This paper aims to address and expand upon these points, specifically within the context of the Republic of the Marshall Islands (RMI), in order to formulate a robust, flexible, and self-refining framework for the production of sustainable and resilient housing. It emphasizes sociocultural practices based around housing construction and design to develop culturally supportive housing, local capacity, and recenter localized knowledge systems in housing design.

Housing adaptations for remote and urbanized atolls are explored through capacity building and knowledge exchange, collaborating with cultural stakeholders in the RMI. Field surveys of housing across four atolls provide analysis of current building practices, material use, and cultural appropriateness, while a new *Dwelling Ecosystem* prototype tests new integrations of local knowledge and materials, and scalability.

Introduction

It is believed that the first form of shelter was built more than 500,000 years ago. Since then, buildings have evolved tremendously from simple dwellings that provide shelter to complex structures that are multifaceted and technically complex, reflecting changing needs of society.

Today, buildings consume a vast quantity of resources, resulting in natural resource depletion and environmental degradation. The global building sector is aware that current methods of building construction and operation need to be replaced with sustainable methods and processes. Hence, sustainable design thinking is a prerequisite in building design and construction practices. We believe that the built environment sector must move beyond sustainability as "green architecture" and begin to think holistically of ecological resilience.

According to the American Energy Information Administration (EIA) and International Energy Agency (IEA),world-wide energy consumption will continue to increase by 2% on average per year. A yearly increase by 2% leads to a doubling of the energy consumption every 35 years. This means the world-wide energy consumption is predicted to be twice as high in the year 2040 compared to the year 2007[1]. The building sector (residential and commercial) consumed 40% of total energy in 2009 as shown in figure 1.1. Residential and commercial consumption are both building consumption.

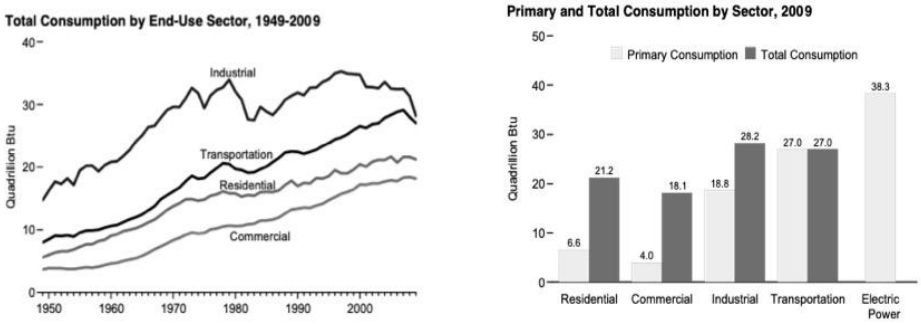

Figure 1.1. American Energy Administration line graph depicting total consumption of end-user sector (industrial, transportation, residential, and commercial) during the period 1949-2019 and bar graph depicting primary and total consumption by sector (residential, commercial, industrial, transportation, and electric power.

Over consumption and irresponsible utilization of resources within the building industry has led to dwindling natural resources and the degradation of the environment. According to Kajikawa, Inoue and Goh[2]. Seeing as pollution and resource use stemmed heavily from buildings and building materials, Hendrickson and Horvath argue new practices in building construction have to be adopted to help rectify the problem[3].

Dwelling as Ecosystem

[1] American Energy Administration
[2] Kajikawa, Inoue, and Goh 2011
[3] Hendrickson and Horvath 2000

The meaning of dwellings has been studied from many different perspectives, such as anthropology, psychology, phenomenology, sociology, and environment-behavior studies. A dwelling is an individual's primary anchor in the environment. It may serve many functions, such as shelter, privacy, security, control and status[4]. Ecosystems are dynamic entities. The tendency of an ecosystem to remain close to its equilibrium state, despite disturbance, is termed its resistance. On the other hand, the speed with which it returns to its initial state after disturbance is called its resilience[5]. The concept of *Dwelling Ecosystem* is to respond to both the environment and individual's needs positively while minimizing the negative impact on the dynamics and strengthening resilience to threats and crisis. The process of dwelling must be dynamic and respond to both the inhabitant and environment.

Precedence of ecological design can be found in many traditional dwellings, as apparent in the work of Paul Oliver[6] and Marcel Vellinga[7].Yaodong or "house cave" is a particular form of earth shelter dwelling common in the Loess Plateau in China's north. The earth that surrounds the indoor space serves as an effective insulator, keeping the inside of the structure warm in colds seasons and cool in hot[8]. These traditional dwellings have been regarded as sustainable designs based on traditional ecological knowledge. The igloo is another well known example of traditional building practices that are ecologically sound. Associated with Canada's central arctic and Greenland's Thule area, the outside temperature may be as low as -45°C, but on the inside the temperature may range from -7 to 16°C when warmed by body heat alone[9]. Paul Oliver's *Encyclopedia of Vernacular Architecture of the World*[10] and Jarzombek's *Architecture of First Societies*[11] provide many more examples demonstrating the application of traditional ecological knowledge in the design and construction of dwellings. The two characteristics of traditional dwelling to obtain materials from local sources and to take the measures suited to local conditions introduce the ecosystem adaptability and the potential of its integration with vernacular architecture[12].

Another major aspect of *Dwelling Ecosystem* is its life cycle. Life Cycle Cost Analysis (LCC) is a method to assess the total cost of owning, constructing and maintaining a facility, up until its demolition. It gives an overall idea of how much it costs to keep a facility running at a certain level over a period of time[13]. Life Cycle Assessment (LCA) on the other hand is a technique used to assess and evaluate the materials and energy flow of a project, through the use of a detailed inventory. With such an inventory at hand, it becomes easier to evaluate the potential impacts associated with the input and release of energy and materials of a project[14]. LCC and LCA clearly calculate the expenditures of the building, and how it might impact the surrounding environment. LCC can also be applied to analyze the long-term savings that could be achieved in an energy-efficient building. However, LCC and LCA are

[4] Henry and Coolen 2006
[5] Chapin et al. 2002, pp. 281-304
[6] Oliver, Paul 2007
[7] Vellinga, Marcel 2006
[8] Ivana 2003
[9] BEE453 Spring 2003
[10] Oliver, Paul 1997
[11] Jarzombek, Mark 2013
[12] Li Ting 2007
[13] Hunkeler and Rebitzer 2003
[14] Hunkeler and Rebitzer 2003

often criticized for operating within a linear rather than circular economy[15]. This study aims to shed light on materiality, resource use, and life cycle assessment within the ecological paradigm of future vernaculars.

The study of building life cycle brings up the awareness of a process-based design logic in the proposal of resilient housing rather than a product-based approach. Considering the expenditures of the building and its impact on the environment, in the context of Pacific atoll nations, materials used in the construction of housing should include as more natural local materials and as less imported materials as possible. Aside from the ecological benefits by implementing natural local material, "it would also be advantageous to develop economical and robust building systems that limit the quality of imported material and that are instead fabricated and constructed locally[16]." In this sense, a framework of housing industry related job market is created, which turns a house from an end product into part of the system. Other elements that could be involved in the frameworks that support systemic sustainability and resilience within these regions includes but not limits economic, cultural and political aspects. A process-based housing design considers different aspects and phases of the house in its life cycle in relation to the natural, socioeconomic, and cultural environment. Furthermore, the dwelling and its systems of parts become part of a larger habitation ecosystem, aligned with local knowledge and customs.

The Habitation Ecosystem of a Pacific Atoll Nation

This paper examines issues of ecological resilience and process-based dwelling through the context of vernacular transformations in the Republic of the Marshall Islands (RMI) and the implications of socio-cultural evolution on the resilience of the built environment. Existing housing models in Micronesia, which are heavily influenced by foreign aid and building practices from the United States, are rarely if ever responsive to the ecology of place. Even structure designed to be climatically adaptive and resilient tend to be more resistant than resilient[17]. Design solutions for housing in this region fail to recognize the importance of process, central to island cultures. Rather, these solutions are product driven, reliant on imported material and technology rather than local material and local construction knowledge. Imported solutions fail quickly as they are unresponsive to a holistic immersion of context and costs are prohibitive for the majority of the population. As a counterpoint, this research aims to build a more viable framework for pursuing resilience and sustainability at a range of architectural and community scales.

Habitation in the Marshall Islands can best be described as the marriage between culture and the natural environment. Spatial responses to the environment are driven by the ecology of place in unison with the cultural practices and protocol of the Marshallese – albeit, cultural practices have evolved with the introduction of Western and Japanese influence. This dialectic relationship of culture-environment can be understood through the transect of the atoll landscape from lagoon to ocean and its relationship to spatial organization. The traditional settlement of Marshallese communities occurred on the largest islet of the atoll, which geomorphologically

[15]Ayres, Robert 1995; Pelletier, Nathan and Tyedmers, Peter 2011
[16] Rockwood, David 2015, pp 4
[17] Rockwood, David et al. 2015

occurred on the western end of the atoll formation[18]. This islet formation created a protected zone on its eastern shore along the lagoon; along this shore at the widest section of the islet provided the safest place for human settlement. Thus, early settlement in the RMI occurred on the largest islets of islands along the central eastern shore. Examining a transect (Figure 2) of this zone provides a narrative of the culture-environment relationship that drove an environmentally responsive, resilient and sustainable pattern of habitation; traditional ecological knowledge maintained a balance for community resilience and ecological resilience. Traditional land tenure in the RMI, known as the *weto* system was derived from the ecological knowledge of the ecosystem.

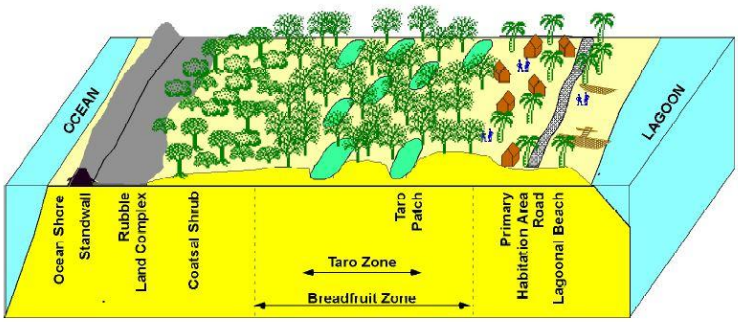

Figure 2: Transect of Laura Village, Majuro, RMI (Spenneman 1990).

A *weto* extended from the lagoon reef to the ocean reef and provided the necessary resources for a clan to thrive. The system of habitation on the *weto* includes resource management, land-use, socio-spatial constructs, and systems of activity – core components in understanding the contribution of vernacular architecture to sustainability. Figure 3 demonstrates the predominant settlement along the eastern shore along the lagoon and the conservation of forested areas. Together with the *weto,* the identifying artefacts of the Marshallese vernacular house is the coral spread (see Figure 4). The land system is the fundamental to understanding dwelling.

[18] Spennemann 1996

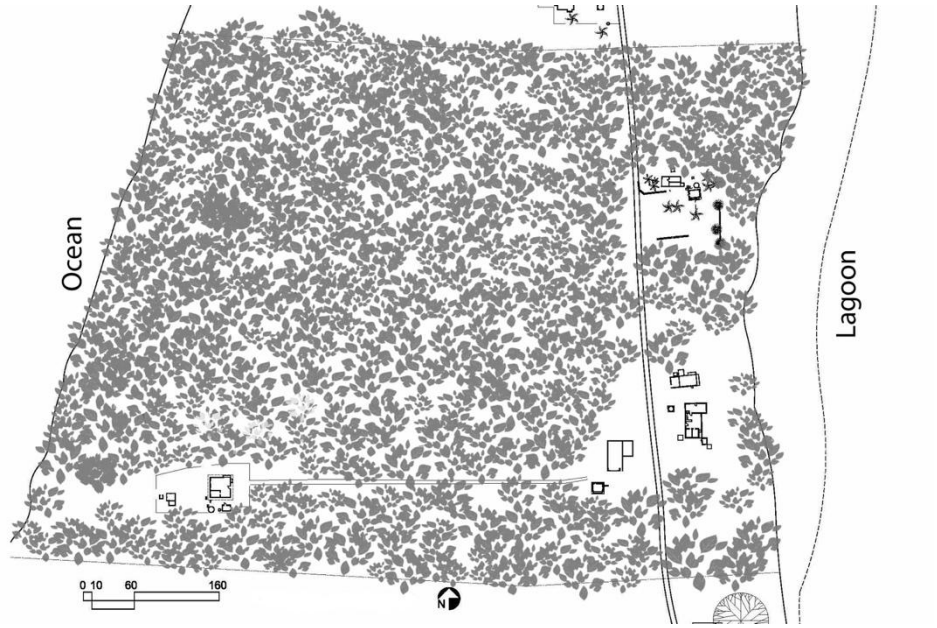

Figure 3. An aerial site plan of a *weto* on Namdrik Atoll. The ocean is to the left of the land and the lagoon is to the right of the land. The openings in the canopy are covered in coral gravel and designate dwellings. The lower dwelling along the lagoon is the *alap's emlapwoj*. Drawing by Author.

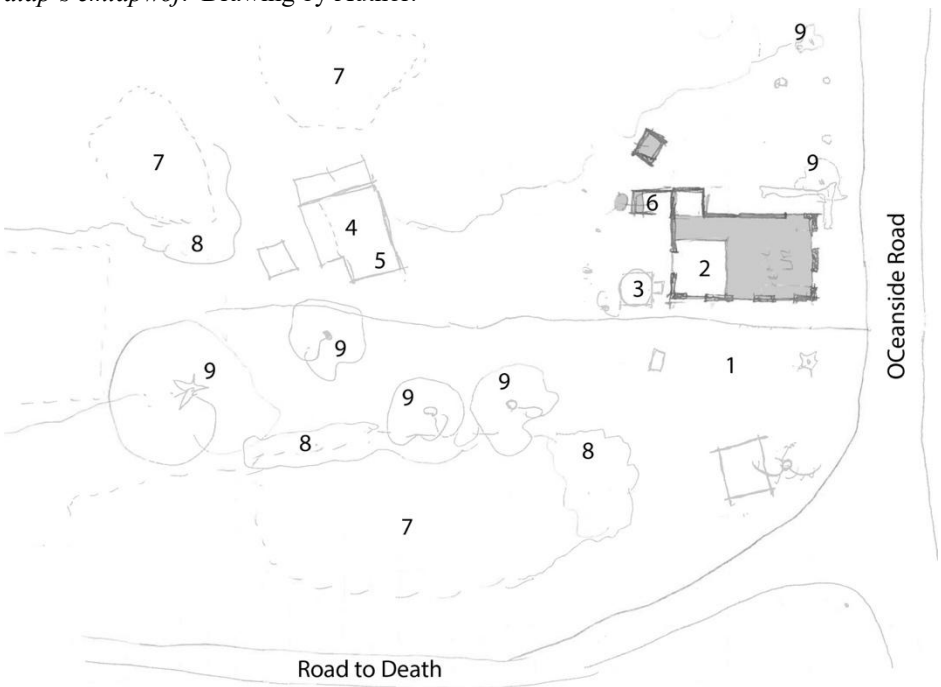

Figure 4. 2018. The coral spread and vernacular house site design found on Laura, Majuro. A traditional housing pattern of the Marshall Islands. 1. Coral Gravel; 2. Living/Sleeping House; 3. Water Cistern; 4. Cooking House; 5. Open Fireplace; 6. Outhouse; 7. Taro; 8. Banana patch; 9. Breadfruit tree. Drawing by Author.

Three important cultural aspects of the Marshallese dwelling system are important to developing a meaningful process for the design and construction of future dwellings. These are 1) togetherness, 2) the cookhouse, and 3) multi-generational living[19]. In addition to these three aspects, architecture built to meet needs[20] is fundamental to the process. Togetherness is demonstrated through the clustering of dwellings, which conserved arable land and natural resources. Togetherness also strengthened community cohesion and cultural practice. It is arguably an essential component of Marshallese culture. The cookhouse is central to the extended family and represented the sharing of resources – it symbolically links the family to the resources they rely on for sustenance and thus the natural ecology of the island. Multi-generational living allows for the dissemination of knowledge across generations. These three aspects are spatial manifestations of the culture-environment dialectic.

Dwelling Vulnerability Created by Outside Influence

Understanding and evaluating existing housing models is essential to understanding the system and working towards systematic change. Together with understanding traditional settlement patterns, ecological principles come to light. While aspects of traditional dwelling and settlement persist in the Marshall Islands, Western and Japanese influence has created noticeable shifts. Understanding the outcome of these shifts in contemporary social, political, and economic dynamics is important to realizing an impactful process. Current building and design practices in the Marshall Islands as well as elsewhere in Oceania are not responsive to climatic and cultural parameters.

From foreign disaster recovery aid to housing projects under the United States Department of Agriculture's (USDA) Rural Housing Self-Help Program, western influence in building and spatial design has had lasting impacts on the built-environment of the Marshall Islands since World War II. A few typical examples are provided here for reference; all of which have impacted the building culture and housing change in the Marshall Islands[21]. Figure 5 represents a typical Federal Emergency Management Agency (FEMA) housing unit first developed and implemented in Saipan following Typhoon Pamela in 1976. This post-disaster shelter was deployed on Jaluit and Namdrik following the devastation of Typhoon Alice in 1979. This was a departure from the post-disaster recovery strategies following the typhoon season of 1958 which utilized collective labor for reconstruction of locally produced dwellings. Figure 6 depicts a concrete dwelling with slab on grade from the USDA plan book, which is the typical layout and structural design for concrete dwellings in the RMI. This is one of the most common housing typologies found in the Marshalls. Figure 7 depicts a typical make-shift dwelling on Namdrik. Make-shift dwellings tend to be constructed of a mix of local materials, recycled corrugated metal sheets, and recycled dimensional lumber and plywood. Lastly Figure 8 represents a typical cook-house constructed of primarily local material with a pandanus paneled roof. The represented dwellings are sited on the *weto* and comprise part of the habitation system. While the typhoon house and the make-shift house are primarily used for sleeping, the USDA house provides space for sleeping, eating, working, cooking, and socializing. The transformation in the common housing typologies represents a change in spatial utilization from outside to in, or from public to private.

[19] Miller, James 2018
[20] Oliver, Paul 2007
[21] Rensel and Rodman 1997

Figure 5. Post-disaster shelter deployed by FEMA after Typhoon Alice devastated Namdrik and Jaluit atolls, RMI. This wood framed structure with concrete slab on grade, is a one room dwelling used primarily for sleeping and crafts making.

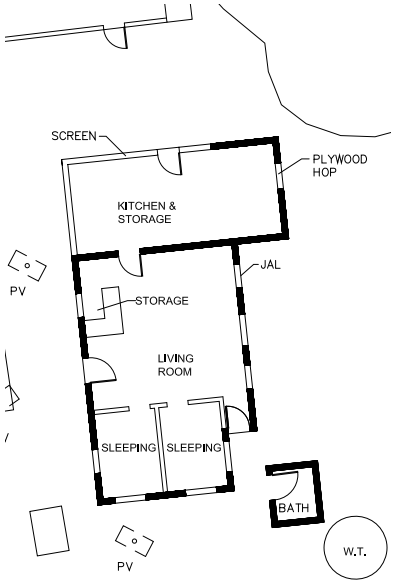

Figure 6. Typical concrete dwelling with concrete slab on grade and structural frame. This dwelling has three rooms with a detached bathroom and a woodframed addition to house a kitchen and storage area.

Figure 7. A typical self-built dwelling on Namdrik, which is similar to self-built dwellings found on Majuro. It is constructed of recycled imported building materials and used primarily for sleeping.

Figure 8. A typical cook house constructed primarily of local materials as evident in the pandanus paneled roof.

The typical dwelling unit in the Marshall Islands, demonstrated by the USDA

house in Figure 6, is typically constructed by foreign contractors and built of imported materials. This is also the model of a house that the proposed *Dwelling Ecosystem* project is a counterpoint to. This typical model represents basic construction methods of the United States that are neither climatically responsive nor energy efficient, furthering the issues of unsustainable building practices. The starting price for this type of dwelling unit is approximately $80,000 USD and comprises of concrete post and beam construction with coated rebar, painted when cut; 15 centimeter concrete masonry unit (CMU) exterior walls; 10 centimeter CMU interior walls; plastic moldings; treated baseboards; treated wood at all interior and exterior members; 25cm x 35cm concrete continuous footings; concrete block infill with coated rebar; treated fascia boards; aluminum corrugated roofs; fiber cement boards for interior walls and soffits; plaster finish; small windows (either jalousie or aluminum sliding); and mini-split air conditioning units. This dwelling typology is not well suited for atoll conditions near the equator.

A few models of more innovative dwelling construction are present in the RMI, but these are few and far between, typically constructed by non-natives. One such example, completed in 2019, utilizes PVC-lined concrete foundations to mitigate termite infestations and minimize harmful salt intrusion into the steel-reinforced concrete. It is located directly adjacent to the lagoon and oriented to accept breezes from the prevailing winds, which provides ample natural ventilation, but could become a vulnerability in high winds. Its wrap-around porch assists in climatic control, and the location of entry doors attempts to protect from salt spray. Figure 9 depicts this new housing typology on Majuro, RMI. Though an improvement, this dwelling still relies heavily on technical expertise, imported materials, and construction methods.

Figure 9. Photograph of house completed in 2019 in Majuro, RMI constructed of PVC pier foundation and wood framed construction. It demonstrates slight innovations in housing design for Majuro.

Methodology

To formulate a robust, flexible, and self-refining framework for the production of sustainable and resilient housing, we have incrementally developed a design process, responsive to the nuances of socioeconomic, cultural and political fabrics. This is sometimes referred to as "slow-design," which we believe to be critical to the first prototype attempt, especially when working in a cultural setting not our own, but that could be slightly streamlined if other versions or sites were to be pursued in the future. Through a process-based approach, we emphasize socio-cultural practices based around housing construction and design to develop culturally supportive housing, local capacity, and recenter localized knowledge systems in housing design. This process attempts to place community stakeholders in the driver's seat, in collaboration with the design and build team.

Our process tries to immerse itself in the social, economic, and cultural context of the community; local knowledge (ecological, spatial, traditional) is central to the process. We work through a social entrepreneurship mindset that is social impact driven, and seek opportunities for economic development through the design, construction, and life of the dwelling – circular economy. The process tries to examine how a singular project can have an upstream impact on environmental and community resilience. Lastly, while we are wary of infeasibility when trying to innovate or create new solutions, we believe that striving to achieve some simple form of 'beauty' in the process can help to allow the project to become a welcomed symbol of the community stakeholder(s) and encourage a sense of pride of place.

Housing adaptations for remote and urbanized atolls are explored through capacity building and knowledge exchange, collaborating with cultural stakeholders in the RMI. Field surveys of housing across four atolls provide analysis of current building practices, material use, and cultural appropriateness, while a new *Dwelling Ecosystem* prototype tests new integrations of local knowledge and materials, and scalability.

Process-Based Project

Several years ago, the RMI developed initiatives to develop downstream economies for their coconut forests within the framework of the United Nations Sustainable Development Goals[22]. As part of this program, the country has begun felling senile coconut trees, replanting forests, and has invested in portable saw mills to process recently felled or fallen trees. This initiative provides an opportunity to fill a current gap (i.e. the need for the potential coconut lumber industry to have relevant and feasible projects for which to use the lumber), as well as integrate a housing program within the broader national development goals based on ecological principles. Thus, this became the inpetus for our development of a process-based *Dwelling Ecosystem* model for the RMI.

[22] https://sustainabledevelopment.un.org

Together we identified project goals and criteria for success that led to the development of the project. These are:

- Better to be slow and great, than fast and so-so. Take time to do it right.
- Create something that is a source of pride.
- Must be actually feasible, but be an example of good design that is climate specific.
- Design systems for flexibility (massing, cost, scalable, applicable across the Pacific)
- Community first to create livelihoods and positive externallities
- Design for coconut lumber, but maintain flexibility for alternative materials, including standard 2x dimensional lumber.
- Should be built within RMI cultural traditions.
- Show the value of design in fostering community-based development.
- Offer competitive cost-points (per USDA housing, typical construction).
- Build local capacity from the start, and beyond the finish.

Initially going slow involves research, gathering information to understand the context and culture. Initial slowness is also important to build relationships with experts in the field and to build a strong team for further developing the model and increasing local capacity.

After fires ravaged the dwellings of a family in Laura, we were approached by a non-governmental organization to assist in improving the housing design for this family and develop a more effective housing model for Majuro. Figure 10 depicts the aerial view of the *weto* this family inhabits and figure 11 provides a closer aerial of the site. This client became the foundation for the project and the development and testing of the model. The first site visit led to a basic understanding of site, family needs, and a study of typical building practices and traditional methods. We developed an understanding of the land and its significance to the family. Drawing from the client's desires and cultural understandings, we discovered nuances that sometimes may counter preconceived understandings of cultural housing patterns. Once again, this demonstrated why initially moving slowly is beneficial.

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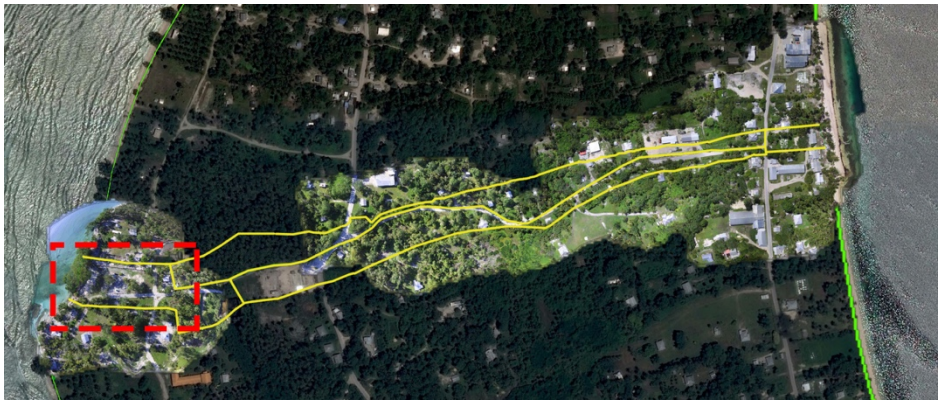

Figure 10. Aerial photostich of the *weto* the site for the family's house. This is located at the center of Laura islet at the widest part. The land in this transect is an important part of the cultural heritage of the Marshall Islands.

Figure 11. Aerial image of the specific site with approximate boundaries. The coral spread is evident in the center of the green rectangle. This was the location of the house that burned down.

Findings

Through preliminary interviews and analysis of existing housing models, we started to consider how spatial organizations may be more reflective of everyday cultural practices. The system of habitation as previously explained, which had decentralized / separate spaces for has shifted over time, leading to more singular, centralized structures in which almost all household activities take place under one roof. However, this singular model is not always effective to meet family needs, and puts constraints on the ability to share spatial elements such as the cookhouse and bathroom, given that in a singular model, potential sharers must move through one's private space. Our model looks at a partial return to the traditional, which involves conceiving of the dwelling as comprised of multiple spatial elements. This 'exploded / decentalized' model increases the amount of envelope required, but helps with airflow and separation of living/sleeping space from washing or cooking space, while better allowing for the potential sharing of elements. There are always tradeoffs in meeting cultural-spatial needs and integrating the structures into the *weto* for collective living. The separate spatial elements also allow for limiting the number of toilets and kitchens and cookhouses (whereas one could be shared), while increasing the amount of private sleeping quarters, and potentially lessening the need to invest in and construct an entirely new singular dwelling from scratch when demand for more living space is needed. Taking into consideration materiality, spatial design and structure, it provides opportunities for minimizing materials needed to withstand typhoons to communal

spaces such as the cookhouse while maximizing the use of traditional local materials and methods such as pandanus panels for covered breezeways and transitional walls. Here, learning from the land becomes essential in understanding how family living responds to its resources.

In our interim stages of the process-based project, we have developed initial site analysis, site design, and a preliminary dwelling design. After initial consultation with the client regarding preliminary design, it was made clear by the family that locating the house within the existing coral spread was not desired. The assumption was made based on research into culturally appropriate siting of dwellings; however, the adjacent area demonstrated in the site schematic in Figure 11 has privacy created by a patch of trees. Additionally, the cookhouse and toilet would be located downwind.

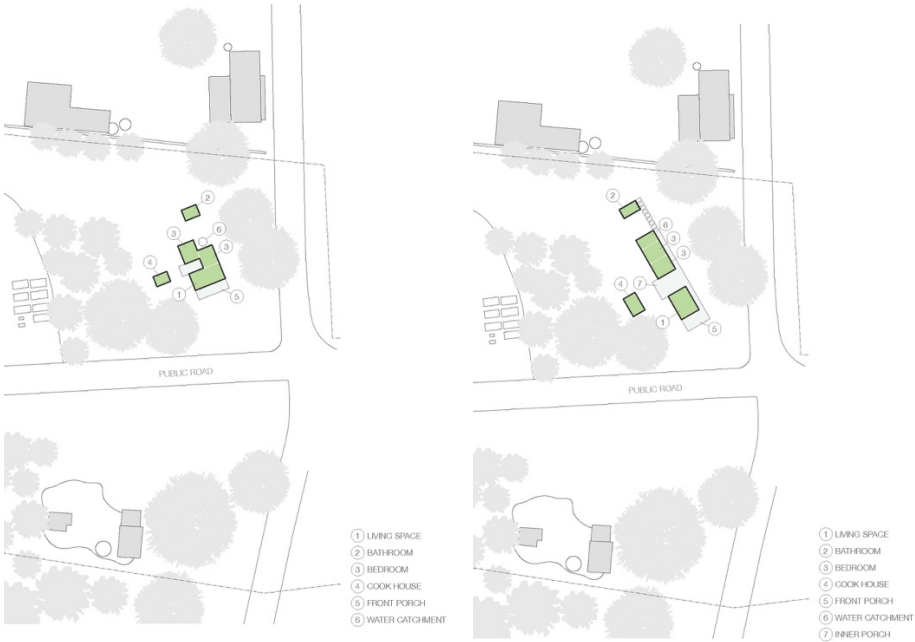

Figure 11. Dwelling configurations on the site.

To further the investigation of locally sourced coconut lumber materials, we brought onboard the navigator and expert outrigger canoe craftsman, Alson Kelon of WAM (Canoes of the Marshall Islands) to the project team, who will be the cultural advisor, assist with workshops, and help to create community connections, as well as opportunities for local youths to gain skills and experience. Bringing him onboard has helped further define gaps locally – as previously mentioned, the budding coconut lumber industry has been in need of a model project, while WAM has been in need of a project in Laura, because it's location on the other side of Majuro Atoll has been difficult to reach for locals in Laura due to its far distance and the investment in time and money that it takes to commute.

Next steps defined through this methodology are to develop a partnership with WAM, conduct more research into the viability of coconut lumber for house construction, and further develop plans and site design that meet the needs of the client.

Conclusion

We have tried to discuss a few of the implications of contemporary building practices in the Marshall Islands, as is relatable across Oceania. The "status-quo" building practices generally further vulnerability and continue extractive practices foreign to place. They are opposed to the land-based practices of communities and their ecological resilience. Through this *Dwelling Ecosystem* project, we aim to introduce another evolution of dwelling design and construction practices that produces more climatically engaged structures than the status quo.

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